

GCE

Physics A

Unit **G484**: The Newtonian World

Advanced GCE

Mark Scheme for June 2017

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All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

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Annotations

Annotation	Meaning
	Benefit of doubt given
	Blank Page
	Contradiction
	Incorrect Response
	Error carried forward
	Follow through
	Not answered question
	Benefit of doubt not given
	Power of 10 error
	Omission mark
	Rounding error
	Error in number of significant figures
	Correct Response
	Arithmetic error
	Wrong physics or equation

Annotation	Meaning
/	alternative and acceptable answers for the same marking point
(1)	Separates marking points
reject	Answers which are not worthy of credit
not	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
()	Words which are not essential to gain credit
—	Underlined words must be present in answer to score a mark
ecf	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

Subject-specific Marking Instructions

All questions should be annotated with ticks where marks are allocated; One tick per mark.

Question		Answer	Marks	Guidance
1	a	Energy of $\alpha = 5.2 \times 10^6 \times 1.6 \times 10^{-19}$ ($= 8.32 \times 10^{-13}$ (J)) $E = \frac{1}{2} mv^2$ so $v = \sqrt{\frac{2 \times 8.32 \times 10^{-13}}{6.6 \times 10^{-27}}}$ $= 1.6 \times 10^7$ (m s^{-1})	C1 A1 A0	Must see some working Allow: Max 1 mark for 4×10^{16} (not converting to J) or 1.6×10^4 (not converting MeV to eV) 5.1×10^5 (using keV rather than MeV)
	b	Any three from <ul style="list-style-type: none"> • Total momentum of system / particles is conserved (as there are no external forces) / Increase in momentum of Sr nucleus equals decrease in momentum of alpha-particle • (Electrostatic) force (of repulsion) acts on (Sr) nucleus • (By Newton's 2nd law Sr) nucleus accelerates (away from alpha particle) • Sr acceleration increases and then decreases (to zero) • Force on Sr nucleus \propto rate of change of momentum of alpha particle. (AW) 	B1 \times 3	 momentum / accelerate(s) / acceleration must be spelled correctly to score corresponding mark
	c	(Momentum is conserved) $6.6 \times 10^{-27} \times 1.6 \times 10^7 = 1.3 \times 10^{-25} \times V$ $V = 8.1 \times 10^5$ (ms^{-1})	C1 A1	Possible ECF from (a) Allow full marks for use of 2×10^7 for speed of alpha particle giving $V = 1.0 \times 10^6$ (m s^{-1})
	d	$\Delta(mv) = 2 \times 6.6 \times 10^{-27} \times 1.6 \times 10^7$ ($= 2.11 \times 10^{-19}$) $F\Delta t = 4.8 \times \Delta t = 2.11 \times 10^{-19}$ $\Delta t = 4.4 \times 10^{-20}$ (s)	C1 A1	Possible ECF from (a) Allow full marks for use of 2×10^7 for speed of alpha particle giving $\Delta t = 5.5 \times 10^{-20}$ (s)
Total			9	

2	a	(Fig. 2.1 shows) a and x are in opposite directions	B1	Allow a is towards the equilibrium position
		(Fig. 2.2 shows that magnitude of) a is proportional to x because graph is a straight line <u>through the origin</u>	B1	Reason must be given
	b	$\text{gradient} = \omega^2 = \frac{40}{50 \times 10^{-3}} = 800$ $T = \frac{2\pi}{\omega} = \frac{2\pi}{\sqrt{800}} = 0.22 \text{ (s)}$	C1	Allow : use of equation and one point from graph
	c	$[k] = \left[\frac{ma}{x} \right] = \frac{\text{kg} \times \text{m s}^{-2}}{\text{m}}$ $[k] = \text{kg s}^{-2}$	C1	Allow: C1 mark for any subject
			A1	
		ii $\frac{k}{m}$ is gradient $\frac{k}{m} = 800 \text{ (s}^{-2}\text{)}$	A1	Possible ECF from (b) Ignore sign
	d	<ul style="list-style-type: none"> The period / frequency of the oscillations would remain the same Successive amplitude(s) would decrease in magnitude energy is dissipated as heat / thermal energy / work is done against friction (AW) 	B1	✎ amplitude must be spelled correctly to score this mark Allow: 1 mark for bald statement that motion would be 'damped harmonic' or suitable sketch.
			B1	
			B1	

2	e	i	<ul style="list-style-type: none"> • C continues to move in a straight line as the tube rotates (by N1st Law) stretching the spring. • Spring exerts a force on C which provides the centripetal acceleration (by Newton's 2nd law) to rotate C (in a circle of appropriate radius). 	B1 B1	No credit for bald statement of laws. They must be applied to the problem.
		ii	<p>Any four from</p> <ul style="list-style-type: none"> • Measure natural length of spring OR Measure mass of C with balance/scale(s). • Rotate at <u>constant</u> speed and video apparatus and ruler • Measure R from video • Find period T from video and speed v from $2\pi R/T$ • Measure extension from video OR calculate extension, x, from R and natural length • Use spring constant and $F = kx$ /Hooke's law OR substitute M, v, R into $F = Mv^2/R$ to find force F 	B1 x 4	
		iii1	FR / Nm	B1	Must have appropriate unit (ignore any prefix)
		iii2	$m = FR / v^2$ [any subject] mass is gradient of graph	C1 A1	Possible ecf from (iii)1
			Total	19	

3	a	$g = \frac{GM}{R^2}$ $\frac{g_{\text{Mars}}}{g_{\text{Earth}}} = \left(\frac{GM_{\text{Mars}}}{R_{\text{Mars}}^2} \right) \left(\frac{R_{\text{Earth}}^2}{GM_{\text{Earth}}} \right) = \left(\frac{1}{(3400)^2} \right) \left(\frac{(6400)^2}{9.3} \right)$ $g_{\text{Mars}} = 0.38 \times 9.81$ $g_{\text{Mars}} = 3.74 \approx 3.7 \text{ (N kg}^{-1}\text{)}$	<p>C1</p> <p>A1</p>	<p>Allow: use of recalled mass of Earth ($\sim 6 \times 10^{24}$ kg) and G from data tables OR calculation of mass of Earth from $g = 9.81 \text{ m s}^{-1}$</p> <p>C1 mark is for substitution into appropriate formula OR mass of Mars = 6.45×10^{23} (kg)</p> <p>Possible FT from their mass of Mars</p>
	b	<p>i</p> <ul style="list-style-type: none"> • Vertical acceleration on Mars is less than on Earth (AW) • time of fall on Mars is greater than time of fall on Earth (AW) • horizontal distance travelled will be greater on Mars 	<p>B1</p> <p>B1</p> <p>A0</p>	
		<p>ii</p> <ul style="list-style-type: none"> • Value of max height will be too small • g/a will reduce as height increases / $g \propto 1/r^2$ / SUVAT equations only apply if a is constant 	<p>B1</p> <p>B1</p>	<p>Allow 1 out of 2 marks for '<u>air</u> resistance will reduce the height'</p>

	c	i1	<ul style="list-style-type: none"> orbit must be over equator / equatorial period must be one Martian day / 8.9×10^4 s direction of rotation must be the same as that of Mars / must travel in orbit parallel to a point on surface of Mars 	B1 B1 B1	Allow : same <u>angular</u> speed as Mars
		i2	$GM_{Mars} = gR^2 = 3.74 \times (3400 \times 10^3)^2 \quad (= 4.3 \times 10^{13})$ $T^2 = \frac{4\pi^2}{GM_{Mars}} r^3$ $r = \sqrt[3]{\frac{4.3 \times 10^{13} \times (8.9 \times 10^4)^2}{4\pi^2}}$ $r = 2.1 \times 10^7 \quad (\text{m})$	C1 A1	Possible ECF for mass of Mars from (a) Allow: C1 mark for substitution of values into correct equation written with any subject. Allow: $r = \sqrt[3]{\frac{6.67 \times 10^{-11} \times 6.45 \times 10^{23} (8.9 \times 10^4)^2}{4\pi^2}}$ $r = 2.1 \times 10^7 \quad (\text{m})$
		ii	$T = \sqrt{\frac{4\pi^2 r^3}{GM_{Mars}}} = \sqrt{\frac{4\pi^2 \times ((3400 + 9000) \times 10^3)^3}{4.3 \times 10^{13}}}$ $T = 4.2 \times 10^4 \quad (\text{s})$ $\text{number of images} = \frac{4.2 \times 10^4}{25} = 1700$	C1 C1 A1	Possible ECF from their GM_{Mars} in c(i)2 or mass of Mars from (a) Allow : Alternative method using $T^2 \propto r^3$ eg $T = \left(\sqrt{\frac{(12400 \times 10^3)^3}{(2.1 \times 10^7)^3}} \right) \times 8.9 \times 10^4 = 4.2 \times 10^4 \quad (\text{s})$ Allow: 2 out of 3 marks for $T = 2.6 \times 10^4$ (s) leading to approximately 1034 images [uses 9000 km as radius of orbit] Possible FT from their value of T
			Total	14	

4	a	<p>charge flowing = $I \Delta t = 45 \times 10^{-3} \times 1.6 = (72 \times 10^{-3} \text{ C})$</p> <p>number of electrons = $\frac{72 \times 10^{-3}}{1.6 \times 10^{-19}} = 4.5 \times 10^{17}$</p>	A1	
	b	<p>$\lambda = \frac{hc}{eV} = \frac{6.63 \times 10^{-34} \times 3.0 \times 10^8}{1.6 \times 10^{-19} \times 130 \times 10^3}$</p> <p>$\lambda = 9.6 \times 10^{-12} \text{ (m)}$</p>	C1 A1	
	c	<p>electrical power = $I V = 130 \times 10^3 \times 45 \times 10^{-3} = 5850 \text{ W}$</p> <p>rate of heat produced = $0.9 \times 5850 = 5265 \text{ W}$</p> <p>$5265 = m \times 4200 \times 10$</p> <p>$m = 0.125 \text{ (kg s}^{-1}\text{)}$</p> <p>$V = \frac{m}{\rho} = \frac{0.125}{1000} = 1.25 \times 10^{-4} \text{ (m}^3 \text{ s}^{-1}\text{)}$</p>	C1 C1 A1	<p>Allow: electrons energy = $4.5 \times 10^{17} \times 130 \times 10^3$ in 1.6 s.</p> <p>power = $\frac{4.5 \times 10^{17} \times 130 \times 10^3 \times 1.6 \times 10^{-19}}{1.6} = 5850 \text{ W}$</p> <p>Allow: Full marks for correct use of 5×10^{17} electrons. Giving $V = 1.4 \times 10^{-4} \text{ (m}^3 \text{ s}^{-1}\text{)}$</p>
		Total	6	

5	a	i	Selection of two or more points from the curve and calculation of pV for each point or comparison of values hence pV constant / $p \propto 1/V$ / Boyle's law is obeyed	M1 A1	Ignore units in calculation
		ii	<ul style="list-style-type: none"> mass of gas / number of molecules must be constant/fixed Temperature must be constant 	B1 B1	Allow: system must be closed
		iii	Straight line graph with positive gradient negative intercept on the mass axis (equal to mass of piston)	B1 B1	
	b	i	$n = \frac{pV}{RT} = \frac{1.0 \times 10^5 \times (\frac{4}{3})\pi \times 1.0^3}{8.31 \times (273 + 17)} = (174)$ mass = $4.0 \times 10^{-3} \times 174 = 0.70$ (kg)	C1 A1	Allow: 1 mark for mass = 5.6 kg [incorrect radius] Allow: 1 mark for mass = 12 kg [incorrect T]
		ii	$p_2 = \frac{p_1 V_1 T_2}{V_2 T_1}$ $= \frac{1.0 \times 10^5 \times 1.0^3 \times 240}{4.5^3 \times 290}$ $p_2 = 9.1 \times 10^2$ (Pa)	C1 A1	Allow: Use of $p = \frac{nRT}{V}$ with their n from b(i) Allow: 1 mark for $p_2 = 2100$ (Pa) [incorrect T]
		iii	Use of internal energy $\propto T$ $\frac{\text{internal energy at max height}}{\text{internal energy at ground}} = \frac{240}{290} = 0.83$	C1 A1	Not ratio = 1.9 [incorrect T]
			Total	12	

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